HERPETOLOGICAL JOURNAL, Vol. 5, pp. 217-220 (1995)

OBSERVATIONS ON SEASONAL AND DIEL SURFACE ACTIVITY OF THE AMPHISBAENIAN *BLANUS CINEREUS* IN SOUTH-WESTERN SPAIN

C. DÍAZ-PANIAGUA, M. C. BLÁZQUEZ, C. KELLER,
A. C. ANDREU, G. OLMEDO AND J. A. MATEO

Estación Biológica de Doñana (CSIC), Apdo 1056, 41080 Sevilla, Spain

The main activity period of *Blanus cinereus* occurred from March to July, and a second period with lower activity was detected in autumn. Individuals were mainly diurnal, but they also exhibited nocturnal activity in April, June and especially in July. Daily activity appeared to be related to air and surface temperatures, while the annual variation in activity was also related to underground temperature. Recaptured individuals showed little mobility, frequently persisting at the same location. The recapture rate between years was low.

INTRODUCTION

Amphisbaenians have traditionally been a little-known order, owing to their subterranean habits. Until recently, the only European amphisbaenian, *Blanus cinereus*, had been the object of few studies. Some comments on its activity pattern were made by Valverde (1967) and Busack (1978). Salvador (1981) reviewed and compiled the available information on the species. In recent years, more detailed studies have been published on some aspects of the biology of *B. cinereus*, including feeding habits (López, Martín & Salvador, 1991; Gil, Guerrero & Pérez-Mellado, 1993), reproduction (González de la Vega, 1988) and activity and thermal biology (Martín, López & Salvador, 1990; Gil *et al.,* 1993). The two latter papers describe the variation of body temperatures in populations of *B. cinereus* at two localities in central Spain. The species is considered to be a thigmotherm and a thermoconformist, since body temperatures were slightly higher than, but not significantly different from, ambient temperatures. Both studies describe the general daily activity pattern of the species, but do not consider its variation throughout the year. Surface activity was detected only during daylight hours, following a bimodal distribution, with one peak in the morning and another in the afternoon.

In the present study we recorded data on the activity pattern of *B. cinereus* at a southern locality in its range. The study site is situated at sea level and is climatically distinct from the areas where the two above mentioned studies have been carried out. Our aim was to determine the annual and daily activity period of *B. cinereus* in this area, as well as the variation of the latter throughout the year. Only surface activity was recorded, and no information was obtained on underground activity.

METHODS

Field work was carried out at the Doñana National Park (SW Spain), from March 1991 to September 1992. The climate is Mediterranean, with overall mild temperatures. Monthly rainfall and mean temperatures for the study period are described in Fig. 1.

B. cinereus is a common species in Doñana, being present in most biotopes of the area (Díaz-Paniagua & Rivas, 1987). We chose a pinewood of *Pinus pinea* as sampling site, placing a series of 35 cm square stone tiles at 5 m intervals in a 6x5 grid arrangement (n=30 tiles). The area is sandy, with no natural stones, and the tiles were used to attract individuals (Díaz-Paniagua & Rivas, 1987). On each sampling occasion all tiles were lifted, and active individuals of *B. cinereus* found beneath them were counted and identified. Each sampling day was normally divided into seven sampling occasions, with checks made every three hours from 06.00 to 24.00 hr, and only one check in the night interval from 24.00 to 06.00 hr. This last interval was omitted from October 1991 to February 1992. The frequency of individuals found was corrected for this difference in sampling effort according to the ratio of number of individuals captured in relation to the number of sampling occasions in a day. The number of sampling days totalled 57.

All individuals were measured (total length and snout-vent length), weighed and marked with subcutaneous alcian blue dots by using a panjet inoculator

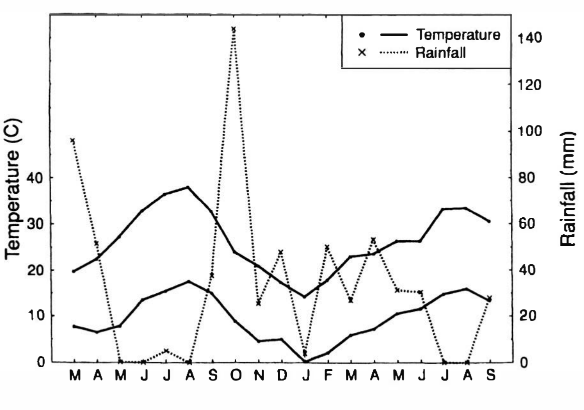

FIG 1. Monthly variation of temperature (minimum and maximum) and rainfall during the study period.

(Wisniewski *et al.*, 1981). On each sampling occasion the following environmental variables were recorded: air temperature (T_a), at open shade and 1 m above the ground; surface temperature (T_s), on the ground, in open shade; underground temperature (T_u), at the bottom of a perforated plastic tube buried 15 cm into the ground and with a closeable upper mouth; and undertile temperature (T_t), always measured under the same tile. Temperature was also measured under tiles where *B. cinereus* individuals were found. Data on relative humidity, daily incidence of radiation and rainfall were obtained from a meteorological station located 2 km away from the study site.

For the analysis of annual activity each animal was considered as one individual record for a sampling day, regardless of how many times it was recaptured on the same day. For diel activity and mobility analyses repeated observations of an individual on the same day were taken into account.

Daily distributions of the number of individuals captured were analysed as circular distributions (Zar, 1984) and their mean angles were calculated as mean activity time. The relationship between temperature and the number of individuals was analysed through non-parametric correlations. The importance of environmental conditions was assessed by comparing the distribution of data characterizing presence and absence of *B. cinereus* by means of χ^2 tests.

RESULTS AND DISCUSSION

ANNUAL ACTIVITY CYCLE

During the study period 31 different individuals were marked, making up a total of 72 individual records, not taking into account recaptures within the same sampling day. Fig. 2 shows the monthly variation of the number of individual records per sampling day (corrected for sampling effort). We found surface active animals from March to October, except in August, which is in accordance with data from central Spain (Gil *et al.,* 1993). The maximum number of individuals was recorded in April, with only a slight decrease in records up to July. No individuals were found under tiles in August, which could correspond with an aestival inactivity period, although maintenance of underground activity cannot be discounted. Martín *et al.* (1990) and Gil *et al.* (1993) also recorded the disappearance of *B. cinereus* under stones in August, and the former suggest that temperatures attain critical values in this microhabitat at that time of year. In Doñana we recorded temperatures of up to 42°C under tiles in August. The same reason could explain the absence of *B. cinereus* under tiles during the coldest months, from November to February, when under-tile temperatures down to 2°C were recorded.

Surface activity was low in September and October, with only a small number of individuals being detected. Bons & Saint Girons (1963) established a dependence between the occurrence of a second activ-

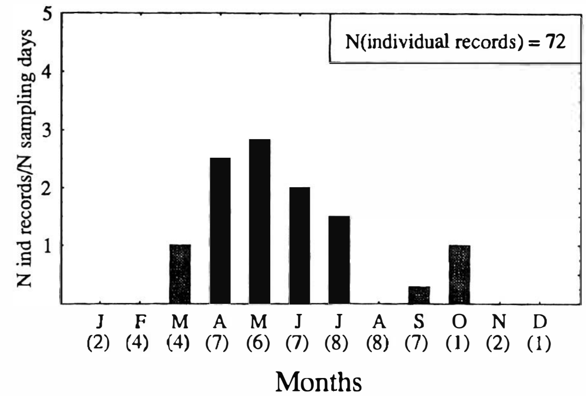

FIG 2. Monthly variation of the number of individuals observed/number of sampling days. (For each month the numbers of sampling days are indicated in brackets).

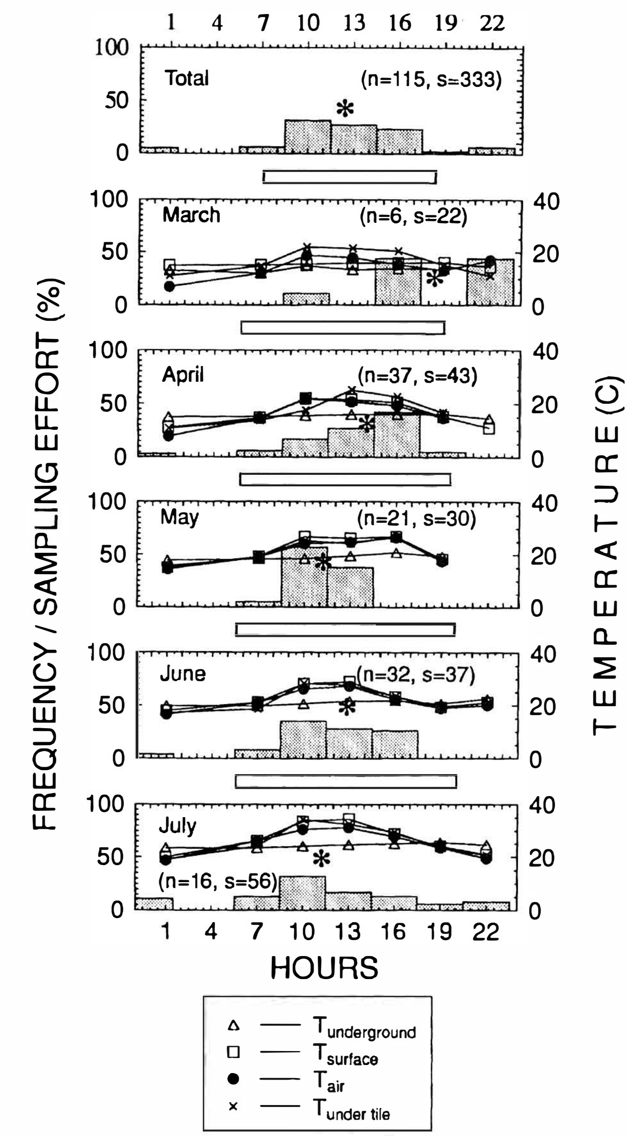

FIG 3. Distribution of the individual records of *B. cinereus* in relation to the number of samples (in %) and variation of temperature through the daily period (classified in 3 hr intervals). Mean activity time is indicated by an asterisk (*) showing the mean angles for each distribution. Bars above each graph indicate the length of the daylight period.(*n*=total number of observations, *s*=total number of samples).

ity period and autumnal rains for the related species *Blanus mettetali.* Our data was recorded during a year of little autumnal rainfall, which could possibly have had a negative influence on autumnal activity.

DIEL ACTIVITY

The diel cycle of *B. cinereus* is shown in Fig. 3 for the total and monthly grouped data (only those months with $n>2$ individuals are shown). The total distribution is unimodal, with the highest number of records concentrated around the warmest hours, the mean activity time being located at 12.30 hr. Individuals were observed in all time intervals considered.

In March and April the mean activity time and the peak of the distribution corresponded to afternoon hours. In the following months, as ground, tiles and air progressively reached higher temperatures, the number of animals found during morning hours increased. From May to July, the highest frequencies were found between 09.00 and 12.00 hr. The widest range of activity time occured in July, when observations of individuals were widely dispersed over all sampling hours. This flexibility in diel activity seems to reflect an accommodation of habits to a range of favourable temperatures, as expected for a typical thermoconformist. Only three individuals were observed in September-October, all of them in the 09.00 to 12.00 hr time interval.

Night-active individuals were found in April, June and July, and could be expected to occur also in May. Nocturnal habits had not yet been described for *B. cinereus*, but have been suggested in general field guides (Salvador, 1985).

ENVIRONMENTAL FEATURES RELATED TO ACTIVITY

The mean variation of all temperature measures over a sampling day is presented for each month in Fig. 3. T_u showed the lowest variation and was only correlated with the distribution of individuals in March (r_s=0.777, P<0.05). T_a, T_s and T_t did vary noticeably ,and time distributions of individuals were significantly (P< 0.05) related with T_s in April (r_s= 0.786), June (r_s=0.847) and July (r_s=0.811), with T_t in April (r_s=0.886) and July (r_s=0.847), and with T_a in June (r_s=0.847) and July (r_s=0.811). These significant relationships indicate that surface movements of animals in these months are influenced by thermoregulatory activity.

The distribution of temperatures recorded during the whole period and those associated with the presence of *B. cinereus* are compared in Fig. 4. Individuals were present under tiles within the following temperature ranges: T_u=13.4 - 27.8°C, T_s=12.6 - 37.0°C, T_a=11.0 - 38.0°C, and T_t=12.0 - 36.0°C. Significant differences between the absence and presence of *B. cinereus* were found for all temperature measures, except T_s, indicating that the species is active within a specific temperature range. It is relevant that T_u showed its influence when considering the whole study period, since this parameter exhibited a wide annual variation but showed minimum variation throughout daily periods.

None of the other environmental variables affected the absence or presence of *B. cinereus* (radiation χ^2=12.6233, P=0.246, df=10; relative humidity χ^2=7.164, P=0.620, df=9). Incidence of radiation varied from 8.5 to 46 kw/cm² over the study period, and *B. cinereus* was only detected from 32.6 kw/cm² on. Regarding relative humidity, we found individuals within the range of 19 to 76%.

MOBILITY

B. cinereus was detected under 22 out of 30 tiles during the study period, averaging 1.16 different individuals/tile (range from 0 to 3). We normally found

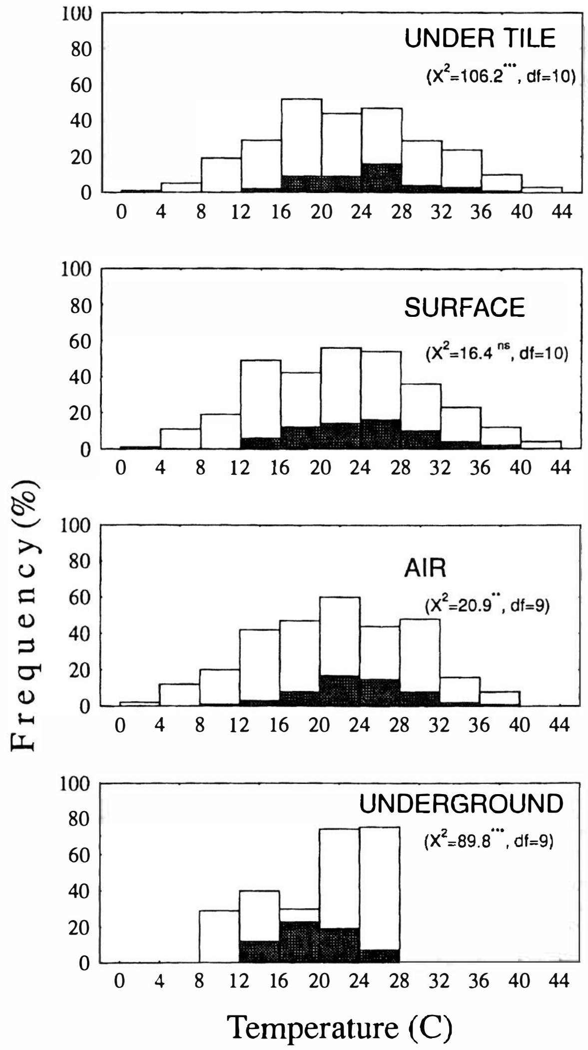

FIG. 4. Distributions of temperatures recorded under tile, at the soil surface, underground, and 1 m above the ground (air) during the study period. The dark bars indicate the data coinciding with detection of *B. cinereus.*

isolated animals, except for four occasions, when two specimens were observed together.

We marked 13 animals in 1991 and 18 in 1992. Only one animal was captured in both years. Thirty-one individuals were observed on 115 occasions, 17 only once and 14 were recaptured from 1 to 13 times. There was low mobility between tiles, since 71.4% of individuals were always recaptured under the same tile, and only 28.6% moved between tiles, covering a maximum distance of 11 m.

Several individuals were found under the same tile over long periods. The strongest site fidelity was recorded from 19 March 1991 to 30 June 1992 for one individual, and from 19 March to 20 June 1991 for another. Time elapsed between first capture and last recapture under the same tile of all other individuals did not surpass 2.5 months.

A very low recapture rate was observed between the first and second study years. One possible cause could be a high mortality; however, no other evidence supported such a hypothesis, since most new individuals captured in 1992 were adults of similar or larger weight and size than those of 1991. Otherwise, mobility could be another possible cause of such high renewal, assuming that, in contrast with the sedentary habits observed for certain individuals, others could be characterized by a higher degree of mobility.

ACKNOWLEDGEMENTS

This study was financed by CSIC-CICYT (project PB-88-0009). Additional funds were obtained from Junta de Andalucia (Group 4088). We also thank the summer student groups at Doñana who contributed to fieldwork, especially to Vanesa Plana. F. Jordá checked our English. Anonymous reviewers improved the manuscript.

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Accepted: 20.9.94